GALENA HILL, YUKON, ECOSYSTEM MAPPING PROJECT

Lisa Knight, R.P. Bio

Access Consulting Group
#3 Calcite Business Centre, 151 Industrial Road, Whitehorse, YT Y1A 2V3

ABSTRACT

The Galena Hill Ecosystem Map (GHEM) was initially developed to provide information about existing plant communities and their growth conditions to guide upcoming reclamation efforts at the historical silver mining area around Keno, Yukon. Disturbed areas and soil covers on mine wastes will need to be vegetated to reduce soil erosion, enable evapotranspiration and eventually integrate with the surrounding landscape. The GHEM project used the guidelines develop by the Yukon's Ecological and Landscape Classification (ELC) working group (ELC Working Group 2011).

Key Words: Ecosystem, Ecozones, Ecoregions, Bioclimate Region, Bioclimate Zone, Bioclimate Subzone, Ecosites, Polygons, Reclamation, Restoration, Revegetation.

INTRODUCTION

Elsa Reclamation and Development Company Ltd. (ERDC), a unit of Alexco Resource Corporation (Alexco), is responsible under a funding agreement with the Governments of Canada and Yukon, for the care and maintenance and the eventual closure of the former United Keno Hill Mine (UKHM) site (Yukon Government 2009). Reclamation planning and implementation has been ongoing since the former UKHM site was transferred to Alexco in 2007. Numerous investigative projects have been initiated to assess the extent and degree of remediation required to stabilize and reduce past mining impacts. The ecosystem mapping project is part of this investigative program. Its main purpose is to inventory the vegetative communities and growth conditions that currently exist in the Galena Hill to inform restoration planning, installation and subsequent monitoring. The intended objectives of the GHEM project are:

- A means to integrate abiotic and biotic ecosystem components that can be presented on one map;
- Develop a record of current vegetation communities and ecological site conditions that can be used as a framework for monitoring ecosystem response to changes;
- A means to locate areas of disturbance, sources for reclamation materials, different successional stages and sensitive areas;
- Provide in situ templates for revegetation efforts;
- Identify possible locations for seed collection and plant stock that match the environmental conditions of revegetation areas; and,
- Use of ecosystem plots that are established during the ground truthing phase as references during closure and reclamation phase for natural vegetation succession, nutrient cycling, and soil elemental profiles.

The first section of this paper will briefly describe the hierarchical framework of ecosystem mapping in the Yukon. Then the general process used in the development of the GHEM. The latter half of this paper is a discussion on the challenges and benefits the GHEM projects and finally recommendations for further studies.

HIERARCHY OF LANDSCAPE ECOLOGICAL CLASSIFICATION

Ecosystem: "An observable unit of the landscape with relatively uniform vegetation (a plant community) occurring on relatively uniform soil conditions" (ELC Working Group 2011).

The main premise of the Yukon Ecological and Landscape Classification (ELC) system is that climate is the foundational environmental factor that influences the type of ecosystems found in the territory. The ELC system begins at a broad spatial level and then as the scale increases more detailed information regarding climate, terrain, soil and vegetation, can be integrated until localized ecosystems can be recognized and classified (RIC 1998a). Over thirty years of research has gone into developing a Yukon focused ecosystem classification system and a formalized approach is still being synthesized (Lipovsky and McKenna 2005). The ecosystem mapping project of Galena Hill drew upon the main concepts that are currently recommended by the ELC. However it must be recognized that information currently available is limited as the Yukon Interior Plateau Ecoregion has only recently been classified to Bioclimatic Zone level. The regional classification hierarchy is briefly described below, and is a work in progress (ELC Working Group 2011).

Bioclimate Region

Bioclimate regions represent areas of broad, relatively homogeneous climatic conditions (Grods and McKenna 2006). The location and orientation of major mountain ranges and plateaus, interacting with territorial-scale weather patterns, create distinct regional climates throughout Yukon. Bioclimate regions generally correspond to Yukon ecoregions (Smith et al. 2004), with a few exceptions. There are ten recognized Bioclimate regions identified within the Yukon Territory, but these are considered provisional as research is still ongoing. The Galena Hill study area is within the northern portion of the Yukon Interior Plateau Bioclimate Region.

Bioclimate Zone

The bioclimatic zones are broad areas of similar regional climate that are characterized by distinctive plant communities and their distribution on the landscape. Bioclimate zones result primarily from changes in elevation and/or latitude. Within each bioclimate region, a bioclimate zone has a characteristic range in elevation and corresponding temperature and precipitation conditions. In mountainous areas, bioclimate zone boundaries are visible as relatively abrupt changes in general vegetation communities along an elevation gradient. In lower elevations or rolling terrain, bioclimate zone boundaries may be subtle and transitional (ELC Working Group 2011).

There are seven provisional general bioclimate zones currently recognized in Yukon; Alpine (ALP), Sub-alpine (SUB), High Boreal (BOH) and Low Boreal (BOL). The Wooded Taiga (TAW), Taiga Shrub (TAS) and Tundra (TUN) are bioclimatic zones that replace BOL and BOH, respectively, in more northern Bioclimatic Regions, and are not of concern in the Galena Hill area. The Galena Hill study area occupies two bioclimatic zones BOH and SUB. Adjacent areas that are within the former UKHM site also have the ALP bioclimatic zone; these areas have not yet been delineated nor interpreted. Table 1 defines the bioclimatic zones found in the Yukon Interior Plateau – North and the percentage of each zone that is represented on the GHEM.

Table 1. Bioclimatic Zones and Definitions

Bioclimatic Zone (elevation range)	Percentage of Total Area	Definition
Low Boreal (200 m to 500 m)	0%	Forested valleys and lower slopes composed of white/black spruce and aspen, moderately developed shrub layer. Non-forested areas include: wetlands, riparian, exposed soil/rock and anthropogenic structures. BOL did not occur within the Galena Hill study area.
High Boreal (500 m to 1100 m)	36.4 km^2 70.9%	The boreal highland forested areas are a mix of subalpine fir and White Spruce with a lichen and moss understory on the majority of the slopes. Late seral areas have Alaskan birch and tall willows as the dominant tree cover. Upper elevation forests are subalpine fir dominant with moderate to well-developed shrub layer. Non-forested areas include: wetlands, riparian, avalanche tracks, exposed soil/rock and anthropogenic structures.
Subalpine (1100 m to 1450 m)	14.9 km^2 29.1%	Open to sparse forest canopy cover, main trees species is sub-alpine fir. A well-developed shrub layer composed mainly of scrub birch and willow replaced forest cover with only a few widely scattered Sub-alpine fir.
Alpine (1450 m+)	0%	Alpine communities include dwarf ericaceous shrubs, dwarf birch (*Betula* sp.), willow (*Salix* spp.), grass/sedges (*Gramineae*), lichen, and bare bedrock at elevations above the tree line on Galena Hill only the very highest portion of its ridgeline was in this bioclimatic zone, less than 1 hectare, so was not delineated out.

At higher latitudes the boundaries of these bioclimatic zones decrease in elevation as annual temperatures are lower, soil development and nutrient cycling is also slower. The Keno area is near the 64° latitude mark. The treeline is at approximately 1300 m on northern aspects and 1360 m on southern aspects. Most of the study area is located on the northwest side of Galena Hill. The study area was restricted between 700 m to 1400 m elevation range.

Bioclimate Subzone

Bioclimate subzones have characteristic vegetation communities reflective of each bioclimatic zone; ALP, SUB, etc. but are in different regions influenced by different climates, for example, the plant communities that grow in the Kluane and Ruby Range Bioclimatic Region will be different than the plant communities in the Interior Plateau Bioclimatic region (ELC Working Group 2011). The Interior Plateau Ecoregion had not been subdivided into Bioclimatic subzones at the time this report was written.

Ecosites

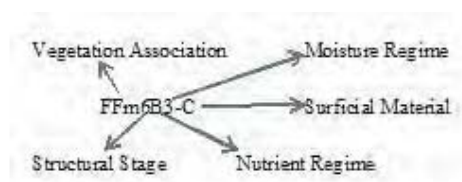
Within a Bioclimatic Subzone, ecosites are organized along landscape position, where certain plant associations occur at predictable locations based on slope, aspect, surficial material, and nutrient and moisture regimes (ELC Working Group 2011). The reference ecosite best reflects the climate of that specific Bioclimatic subzone. Meaning the reference ecosite would be in neutral landscape position that drains water at an equal rate at which it receives precipitation, usually on a moderate slope. The nutrient content of the soil is average and the aspect of the slope would be orientated East or West so solar exposure would be moderate (ELC Working Group 2011). The ecosites have not been formally established for the GHEM. The plant associations found during the GHEM ground truthing phase are situational based, just to verify polygon interpretations.

Ecosites are the most detailed division of ecosystem classification and used at a local scale. Ecosites are defined based on moisture and nutrient availability and landscape position. For example a ridge would shed water faster than it would collect water, so this landscape position would be considered dry and nutrient poor. The other ecosites within the same Bioclimatic Subzone are compared to the reference site according to the differences in moisture and nutrient availability and landscape position. Lower slopes would be moister, richer sites with vegetation association that has plants that require more water for growth as opposed to higher or more exposed sites that would host different plants that are drought resistant. Ecosites have characteristic vegetation associations that are described based on their mature or relatively stable successional phase (ELC Working Group 2011). The GHEM is a first step in defining the ecosites based on topographic position; more work will be needed before ecosite classification for this bioclimatic subzone is achieved.

Ecosystem Polygon Labeling

Each bioclimatic zone can be further delineated into vegetation polygons, which can be further divided into ecosystems that are based on vegetation associations, variations in moisture/nutrient regimes, and surficial materials. Each ecosystem is identified on the ecosystem map using four characteristic components (ELC Working Group 2011):

1) Vegetation association (vegetation)
2) Moisture and nutrient regime of site (soil)
3) Slope/aspect influences (climate)
4) Surficial material (terrain)



When two ecosystem codes are needed, deciles are put in front of each ecosystem units to indicate the percentage of each identified ecosystem that is present in the polygon.

70% Fir-Feathermoss-Mature Stand-Poor Nutrient Level-Submesic-Colluvial

7FFm6B3-C/3EsWi3aC5-F

30% Shrub birch-Willow Short Shrub-Average Nutrient Level-Subhygric on Alluvial

RESULTS

The Ecosystem Map of Galena Hill (draft) is the main outcome of the 2012 ecosystem investigative program. It presents the spatial relationship of the local ecosystems within the study area. Each polygon conveys information regarding vegetation association(s), structural stage, nutrient and moisture regime and surficial material. The different colour hues are used based on leading species of the different vegetation associations.

The 51.3 km^2 area that was mapped included the Galena Hill section of the former UKHM property; the BOH Bioclimatic Zone represented 70.9% which is equivalent to 36.4 km^2. The SUB portion at 29.1% covered 14.9 km^2. There were 156 polygons delineated, interpreted and assigned an ecosystem(s) code on the Galena Hill Ecosystem map.

Information provided from aerial interpretation, plot data sheets, field notes and photographs resulted in 42 different vegetation associations identified (see Table 2). The vegetation associations are tentative as they are based on a limited number of ecosystem plots (36) completed during the ground truth phase.

Surficial materials placement was based on the 1998 Surficial Geology map prepared by J. Bond and aerial interpretation done during polygon delineation. Ground surveys also provided local scale confirmation of underlying parent material from trenches and road cuts.

Nutrient codes are letters A to E, where A is very nutrient poor and E is very rich. Moisture regime codes are numbers 0 to 8, where 0 is very xeric, 4 is mesic and 8 is hydric (water is at or above soil level).

In Table 2 the plant associations, found in the BOH or SUB, are expressed in codes and the ecosystem where they were found is described.

Table 2. Codes and Descriptions of Plant Associations and Ecosystem Codes within GHEM Bioclimatic Zones

Plant Association	Ecosystem Code	Description of Ecosystem
SUB-ALPINE (1100 m to 1450 m)		
Heather-Lichen	HLi	Colluvial - Dwarf shrub communities, heather (*Cassiope tetragona* and Phyllodoce), crowberry (*Empetrum nigrum*), lingonberry (*Vaccinium vitis-idea*) and lichen, a few grasses. Exposed well drained soils. Upper Sub-alpine, exposed rocky area, A(B)2-3.
Shrub Birch-Willow Feathermoss	EsWiFm	Morainal - Moist upper mountain gentle slope, variable aspects, solifluction lobes may be present ground hummocky, often extensive coverage. B3-5
Fir-Sw-Shrubs	FSwSh	Lower Sub-Alpine, mature trees, high diversity of shrub species, often on glacial fluvial deposits or colluvial. B3-5.
Fir-Sw-Feathermoss	FSwFm	Upper/middle slopes, well drained on colluvial medium to coarse soil texture. Varied aspects. Lower Sub-alpine. B4.

Plant Association	Ecosystem Code	Description of Ecosystem
Fir-Shrubs-Feathermoss	FShFm	Open canopy mature fir, higher variety of shrub species, mainly on colluvial over morainal, medium soil texture. Moderate slopes.
Fir/shrub birch-willow	FEsWi	Variable aspects, dry to moist sites F>10% 5-3/B. Fir coverage decreases as elevation increases. Morainal or colluvial.
Fir-Alaskan birch-Feathermoss	FEnFm	Young Forest, morainal and colluvial over morainal. Regeneration after slumping or anthropogenic disturbance.
Fir-Feathermoss-Lichen	FFmLi	Moderate to steep slopes on colluvial. Shallow soils. Few shrubs open to sparse trees. B4-3.
Fir/Feathermoss	FFm	Morainal - Open to dense forests on mountain slopes various aspects. 5-3/B, also in High Boreal.
Carex-dwarf willow	WiCx	Shallow depressions or flat surfaces along cool aspects in upper Sub-alpine. Populated with dwarf willow species like: *Salix arctica*, *S. reticulate*, *S. pulchra* and *S. barratianna*. Other plants encountered were *Festuca altaica*, *Deschampsia cespitosa*, *Carex* sp. on morainal C5-7.
High Boreal (500 m to 1100 m)		
Aspen-Kinnikinnick	AAu	Glaciofluvial - Open/Dense Aspen with variable low shrubs, *Rosa acicularis*, forbs and grasses 4-3/C.
Aspen-Willow	AWi	Moderate to steep slopes open canopies on glacial fluvial
Aspen-Sw-Rose grasses	ASw	Glaciofluvial - well drained, steep slopes, south facing sides of river corridors, B3-2.
Alder-Willow	AlWi	Along riparian edges or old disturbances occasional flooding. Alluvial deposits sand, gravel, cobbles. C4-6.
Alder-Balsam-Popular-Willow	AlBWi	Fluvial - on flood plains deposit frequent flooding sand and gravel. C-6.
Balsam poplar - Willow	BWi	Fluvial - Floodplains, islands and older channels.
Balsam poplar-Shrubs-Forbs	BShFb	Natural regeneration of disturbed areas, where soils have been stripped. Gravel and some sand left, variety of shrubs; alder, willows, roses and Balsam poplar. On cut terraces where water can collect. B4-2.
Sedge-Cotton grass	CxEr	Organic - in fen areas 7-5/B tussocks and open water present, 8-5/B.
Calamagrostis-Sedge	CaCx	Morainal/organic-edges of streams and lakes 7-6/D.
Alaskan Birch-Sw	EnSw	Morainal - Cool, moist N facing slopes, hilltops and terraces. 5-3/B-C.
Alaskan birch-forbs	EnFb	Closed birch canopy, reduced shrub growth, forbs and mosses, gentle slopes North facing slopes C4-5.
Shrub birch-willow-Feathermoss-Sphagnum	EsWiFmSp	Organic - in lowlands with poor drainage, community. 6-5/B.
Lichen-Mosses	LiMo	On colluvial, primary succession. Lichens various forms. Mosses include *Polytrichum*, *Dicranum*, *Racomitrium* and others.

Plant Association	Ecosystem Code	Description of Ecosystem
Sb-Labrador Tea-Sphagnum	SbLeSp	Level to depression, organic, nutrient poor bog, B/ 5-7.
Sb-Sw-Feathermoss	SbSwFm	Morainal, with an organic veneer. All aspects, thick organic forest floor (~30cm) over till, *Ledum* common, over permafrost. B/6-4.
Sb-Shrub mix-Feathermoss	SbShFm	Mid to lower north facing slopes, thick moss carpet on morainal or colluvial over morainal, several species of shrubs, often associate with permafrost.
Sb-Ledum-Feathermoss	SbLeFm	Lower slopes and lowlands on organics. Open to sparse Sb canopy. Often complexed with EsWiFm.
Mixed Shrubs-Forbs	ShFb	Regeneration sites that have exposed soils and less moss cover can also be found under mixed or deciduous tree cover.
Shrubs-Feathermoss-Lichen	ShFmLi	Upper slopes, well drained, thick moss cover with lichen, sun exposed, some forbs, course textured soils, colluvial. B/C3-2.
Sw-Alsakan birch-Feathermoss	SwEnFm	Mixed forest on colluvial or glacial fluvial, previous disturbance.
Sw-Alaskan birch	SwEn	Well drained coarse soils, often found on knolls and colluvial. Shrubs rose, willow, bearberry, Kinnikinnick, graminoids and forbs. C3-4.
Sw-Willow-Crowberry	SwWiEm	Significant slope, cool aspect, deep medium textured soils.
Sw-Feathermoss	SwFm	Upland open to close forest, moderate to well drained slopes variable aspects. B4-3.
Sw- Balsam popular-equisetum	SwBEq	Alluvial - subject to infrequent flooding.
Sw-Balsam popular	SwB	Along waterways lower slopes and lowlands. Glacial fluvial and fluvial-shrub understory if open canopy.
Sw-Willow-Scrub Birch	SwEsWi	Upland forest, gentle slopes, deep medium textured soils. B3-5.
Sw-Scrub Birch-Cladina or Sw-Lichen	SwLi	Significant slope, warm aspect, shallow soils. Xeric to subxeric.
Sw-Alder-Equisetum	SwAlEq	Glaciofluvial - low terraces lower slopes or between channels, infrequent flooding, gentle slopes or flat. 6-4/C.
Willow and Equisetum	WiEq	Fluvial - older floodplains subjected to occasional flooding, 5/C.
Willow-Alder-Equisetum	WiAlEq	Riparian edges, occasional flooding, grasses often present.
Willow-Graminoids	WiGr	Along edges of lakes, ponds and slow flowing streams, alluvial. C 6-8.
Willow-Sedge	WiCx	Along edges of ponds, slow flowing streams or standing water in depressions. C 6-8.

The prevalent vegetative community in the BOH is White spruce-Subalpine Fir-Shrubs-Feathermoss (SwFShFm) and in the SUB it is the Shrub birch-Willow-Feathermoss (EsWiFm). The EsWiFm association is ubiquitous, occurring in both bioclimatic zones, and across the entire elevation range (700 m to 1400 m asl).

During the ground truthing phase several ecosystem plots were permanently established for future monitoring. The plots below were also selected to be used as references or possible seed sources for restoration sites.

Table 3. Selected Ecosystem Plots for Cover Trials and Source

Plot Number	Reasons	Ecosystem Unit(s)	GPS UTM Coordinates
SG004	Pioneering shrubs and forbs growing in very coarse substrate on disturbed land near old adit. Similar conditions to areas needing revegetation. HBOL.	4ShFb3bB2-R: 3LiMo1aA2-R	0482241E, 7088515N
FCW12	Established mature to old growth on northern aspect. Common vegetation association in study area. Background soil mineralization profile. BOH.	SbShFm6B5-Gf	0475958E, 7076246N
CCW9	Shrub dominant ecosystem at 1365 m elevation. Numerous disturbances nearby that are at different stages of natural revegetation, good comparison for SUB revegetation attempts. Possible Reference Ecosite.	EsWiFm3aC4-M	0481339E, 7087938N
FCW3	Exposed colluvial with primary succession of lichen and moss. Adjacent is a submesic low shrub successional stage. Shallow soils and poor nutrient levels.	5ShFm3aB3/5LiMo1bA1	0477593E, 7086423N
NCW14	Typical of road edge tall shrub stage regeneration. Source of shrub cuttings and seed collection for Balsam poplar, willow and alder.	3SwFm5B4C/ 7AlBWi3bB5-C	0478515E, 7089691N
FCW9	Edge of Husky waste pile, natural regeneration in Subhygric-hygric. Low shrubs and graminoids. Potential source of seeds for moister revegetation sites.	SwEsWi5B5/CaCx2bC6	0473916E, 7085984N

The table below lists the plant species that were frequently encountered on naturally regenerating areas, recovering from mining disturbances. Comments regarding how certain plants can be used in restoration are included.

Table 4. Possible Candidate Native Plants for Revegetation Efforts

Species	Comments
Willow *Salix alaxensis, S. pulchra, S. planifolia, S. arbusuloides*	Only use in wet locations and only use the species listed. Willow is the main plant used for staking of live/dormant cuttings and for bioengineered structures.
Poplar *Populus balsamifera*	Only use in wet/moist locations; easily established through staking of live/dormant cuttings.
Shrub birch *Betula glandulosa, Betula nana*	Only plant seedlings grown in a nursery from locally-collected seed. Tolerant of acid soils. Use on moist sites with good organic content.
Alder *Alnus crispa, Alnus tenuifolia*	Only plant seedlings grown in a nursery from locally-collected seed. Tolerant of slightly acidic soils and low nutrients. Use on moist/wet sites that are not alkaline.
Raspberry *Rubus idaeus*	Mesic – sub mesic sites.
Rose *Rosa acicularis*	Mesic – sub mesic sites.
Yellow locoweed *Oxytropis campestris*	Tolerant of drought and low nutrients. Low growing bunches. A nitrogen-fixing forb that is found in dry, granular disturbed areas.

Species	Comments
Showy locoweed *Oxytropis splendens*	Tolerant to drought and low nutrients. Low growing bunches. A nitrogen-fixing forb that is found in dry, sandy disturbed areas.
Bear root *Hedysarum alpinum*	Tolerant to alkaline soils, drought and low nutrients. A nitrogen-fixing forb that grows in a variety of alkaline sediments in disturbed areas at low to mid elevation.
Arctic lupine *Lupinus arcticus*	Tolerant to low nutrients, permafrost, limited drought. A low-growing, nitrogen-fixing forb. Grows mostly on moist soils in disturbed areas ranging from lowland riverbanks to alpine and tundra, also along roadsides.
Yarrow *Achillea millefolium*	Tolerant to alkaline soils, drought, low nutrients. Mostly found in areas with well-drained but poorly developed soil. Produces tiny seeds in abundance.
Wild Rhubarb *Polygonum alaskanum*	Possibility for drier clayey soils. May overgrow other candidate species. Check literature.
Northern rough fescue *Festuca altaica*	Tolerant to low nutrients, drought, high elevation and permafrost. Medium size bunchgrass with low seed yield, but spreads by rhizomes. Widespread, grows in open woods, alpine grasslands, tundra, at all elevations.
Northern bluegrass *Poa alpigena/Poa pratensis*	Tolerant to mildly acidic soils, low nutrients and permafrost. Grows in sandy areas along lakeshores and moist meadows.
Ticklegrass *Agrostis scabra*	Pioneering on disturbed gravelly sites such as roadsides and disturbed areas.
Purple reed-grass *Calamagrostis purpurascens*	Moist woods, meadows, wetlands, lakeshores and clearings; widespread across boreal region.
Slender wheatgrass *Agropyron trachycaulum*	Native of gravelly and river shores, cliffs and talus slopes.
Tufted Hair-grass *Deschampsia caespitosa*	It has a high tolerance of metal-contaminated soils and grows not only in nutrient-rich, poorly drained habitats, but also in well-drained, nutrient-poor soils.

DISCUSSION

The past anthropogenic disturbances have made it difficult to clearly define homogenous ecosystems, as the landscape is mix of different structural stages that occur in close proximity to each other, yet are not large enough to be separated into different polygons. Larger polygons have a higher degree of diversity as a larger area is likely to have more variation in microtopography which influences site growth conditions. The resolution and accuracy of the 1:40,000 aerial photographs were questionable for the detail required at a 1:12,500 scale map. There were areas difficult to decipher due to shadow cast, photo distortion and an inconsistency with the grey scale. Also, gradual change in slope and vegetation makes it difficult to determine a defining line between vegetative types. For these reasons there is inherent error in the placement of polygon boundaries, the polygon as presented on the ecosystem map should be considered at best approximates. Further ground surveys and ecosystem plots are needed to improve the accuracy of the GHEM.

Most of the study area is situated on North and North-easterly aspects, so the vegetative associations listed in Table 2 are reflective of cooler growth conditions. The aerial photography interpretation shows higher diversity of plant communities and geomorphology on the southern aspects. In future investigations, plots can be established on these southern aspects to complete the inventory of vegetation associations found in the local area. There is a wide spectrum of plant associations, one factor is the variation in topography, and the other factor is the numerous disturbances in the area from mining and human habitation over the last 100 years. The Galena Hill Ecosystem Map produce at this stage still requires more input and refinement and should be considered as a draft.

RECOMMENDATIONS

The following recommendations are meant to be incorporated into any future ecosystem mapping endeavours to increase the accuracy and usefulness of this product for reclamation and revegetation in the former UKHM site.

- More ecosystem plots need to be established in polygon types not yet visited, to ensure accuracy of ecosystem labeling;
- More ground plots, transects and visual checks needed to achieve accurate placement of polygon boundaries;
- Aerial photography will need to be updated preferably after the main terrestrial reclamation projects have been completed;
- Control plots that match the growth parameters (aspect, SMR, SNR, surficial geology) of the cover trials need to be established when test sites have been selected;
- Disturbed areas consisted of old mine works, main roads, gravel pits and urban development. These are identified on the ecosystem map as red coloured polygons. A few of these areas are worth further investigation as they are in primary and/or early secondary succession that provide templates for revegetation efforts and have plant species that are pioneers and heavy metal tolerant;
- An active weed monitoring/management program needs to be in place to prevent invasive species encroachment. Several invasive plant species have already been observed in the area. Areas of weed infestation can be shown on the GHEM and monitored;
- Data check and map review needs to be done in coordination with ELC coordinator and technical working group, as ecomapping standards and plant associations are evolving;
- Determine the usefulness of the GHEM in guiding and monitoring the progress of restoration projects as according to nine attributes as laid out in the SER Primer.

CONCLUSION

By integrating the aerial photo interpretation and vegetation survey information, an ecosystem map was produced. The map is the stratification of the landscape into polygons according to a combination of ecological features, primarily climate, terrain, soil, and vegetation.

The Galena Hill Ecosystem map is at a scale of 1:12,500, with 156 separate ecosystem polygons. It is meant to provide guidelines for reclamation and revegetation projects so these areas can eventually integrate into the surrounding landscape and be ecologically functioning. Polygons identified as in early succession can be seed resources for pioneering native plants and references for monitoring the trajectory of reclaimed areas. Certain vegetation associations are better suited for growing on shallow soils over colluvial surficial material, similar to engineered covers. These vegetation communities can be found easily on the ecosystem map and used as a guide. The ecosystem map can also be used as a land management tool and should be viewed in conjunction with planning, e.g., placement of roads, trenches, waste rock, tailings or any other activity that will involve the disturbance of natural areas.

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Overcoming Northern Challenges

Proceedings of the 2013 Northern Latitudes Mining Reclamation Workshop and

38th Annual Meeting of the Canadian Land Reclamation Association

Whitehorse, Yukon September 9 – 12, 2013

CLRA | ACRSD
Canadian Land Reclamation Association
Association canadienne de réhabilitation des sites dégradés

Northern Latitudes Mining Reclamation Workshop

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Polster	Natural Processes: An Effective Model For Mine Reclamation
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NORTHERN LATITUDES MINING RECLAMATION WORKSHOP

The Northern Latitudes Mining Reclamation Workshop is an international workshop on mining, land and urban reclamation and restoration methods. The objective of the workshop is to share information and experiences among governments, industry, consultants, Alaska Natives, northern First Nations and Inuit groups which undertake reclamation and restoration projects, or are involved in land management in the north or in comparable environments.

The first Workshop was held in Whitehorse, Yukon Territory, Canada in 2001 and it has been held every two years since, alternating between Canada and Alaska. The primary sponsors of the Workshop include the Yukon Geological Survey, Indian and Northern Affairs Canada, Natural Resources Canada, US Department of the Interior Bureau of Land Management, and the State of Alaska Department of Natural Resources.

CANADIAN LAND RECLAMATION ASSOCIATION

The CLRA/ACRSD is a non-profit organization incorporated in Canada with corresponding members throughout North America and other countries. The main objectives of CLRA/ACRSD are:

- To further knowledge and encourage investigation of problems and solutions in land reclamation.
- To provide opportunities for those interested in and concerned with land reclamation to meet and exchange information, ideas and experience.
- To incorporate the advances from research and practical experience into land reclamation planning and practice.
- To collect information relating to land reclamation and publish periodicals, books and leaflets which the Association may think desirable.
- To encourage education in the field of land reclamation.
- To provide awards for noteworthy achievements in the field of land reclamation.

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- The Conference Organizing Committee: Alissa Sampson, Andrea Granger, Bill Price, David Polster, Diane Lister, Justin Ireys, Linda Jones, Mike Muller, Neil Salvin and Samantha Hudson.
- The Conference Papers and Posters Committee: Andy Etmanski, Bill Price, Chris Powter, David Polster, Diane Lister and Scott Davidson
- The Conference Sponsors (see next page)
- The Conference paper and poster presenters
- Dustin Rainey, Jocelyn Douheret and Brian Geddes for permission to use their photos on the Cover, Papers and Posters pages, respectively

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